

“Biological condition is the most comprehensive indicator of water body health: when the biology of a stream is healthy, the chemical and physical components of the stream are also typically in good condition.”

National Rivers and Stream Assessment 2008-2009 (U.S. Environmental Protection Agency 2013)

In stream habitat diversity and channel complexity are fundamental components of functional river systems. Reductions in the presence of these components impacts water quality conditions and functional conditions for aquatic species in western rivers (Roni, et al. 2002). Academics, resource agency staff, and restoration practitioners agree that significant intervention to promote habitat diversity and complexity is needed to improve habitat conditions for native fish and aquatic species (Torgersen, Ebersole and Keenan 2012).

Past and in some cases continuing efforts to make farms more productive, keep cities safe from floods, and improve navigation required significant modifications that impact naturally functioning river systems. Flood control and water capture and storage dams were constructed; wood, rocks, and debris were removed from river channels; natural percolation of surface water into groundwater was disrupted by the filling of wetlands, paving of urban environments, and the tiling of farms fields (Roni and Beechie 2013). Not only has the actual fish habitat been disturbed, but the gravels, instream debris structure, and dynamic hydrology required to form and maintain new habitat was also disrupted (Gregory and Bisson 1997). This homogenization, i.e., hardened streambanks, straightened channel meanders, and diverted river water for irrigation, has removed cold water refugia, reduced predation cover for juvenile salmon, and raised the overall river temperatures to levels that impact salmonid spawning, rearing, and migration.

As an example of the effects of homogenization of our freshwater systems, many of our rivers and streams suffer from excessive growth of aquatic macrophytes (Error! Reference source not found.). When aquatic plants grow uninhibited, they can slow river flows by providing resistance to flows. Slower river flows allow sediment to settle out of the water column and into the substrate (Madsen, et al. 2001). These suppressed flows also cannot flush the streambed of sediments. Over time, the streambed substrate fill in with sediment, cuts off the surface water-groundwater exchange, and contributes to higher river temperatures by restricting a valuable source of cold water. The



Figure 1: In Southwest Idaho, the combination of low flows in the Snake River and high loads of sediment has created the ideal habitat for aquatic macrophytes: slow moving, shallow water and an abundant supply of nutrients. As a result, the river looks and functions more like a shallow pond than a large river.

temperature impacts of low flow are compounded by high solar energy loads that warm water temperatures (Poole and Herman 2001). The same conditions that allow for extreme aquatic macrophyte proliferation also limits spawning, resting, rearing, cover, and refuge habitat for native fish species (Groves and Chandler 2005).

When the Clean Water Act was enacted in 1972, one of the biggest issues facing our aquatic ecosystems was discharge of raw sewage and industrial waste from point sources. The Clean Water Act sought to fix this problem by regulating the amount of pollutants entering aquatic systems from the end of pipes. Recently, however, awareness has grown that protecting beneficial uses (a tenant of the Clean Water Act) of the entire ecosystem requires more than end of pipe controls. Protecting beneficial uses requires attention be focused on more dispersed pollutant loading of sediments, nutrients, and thermal **AND** the physical characteristics of rivers and streams. As an example, simply reducing nutrient loads to a river system will not stop the proliferation of macrophytes in highly modified river systems. By broadening our restoration and compliance approach to include physical habitat improvements along with pollutant load reductions, regulatory agencies can better protect beneficial uses of our nation's rivers and streams (Roni, et al. 2002).

The ecological functions and processes of a river can be improved or restored by altering channel characteristics such as flow rates, channel depth and width, and connecting side-channels and alcoves. When these features have been restored to a channel, they can provide substantial and measurable ecological and water quality benefits. In-channel island augmentation or creation, for example, reduces the channel width, which results in higher water velocities. Higher water velocities lead to streambed scouring and can deepen the river channel in places (*Figure 2*). Scouring increases sediment transport within the river, a process that can keep streambed substrate free of silt, which in turn allows for hyporheic exchange flows that can buffer water temperatures (Rehg, Packman and Ren 2005). The installation of large wood structure (log jams) can also increase channel depths (via scouring) downstream of the features (Smith, et al. 1993). These deep pools provide cover and cool water refuge for juvenile and migrating fish and a physical scour pit which now allows for the physical input of river water into the ground water. These are two examples of restoration actions that result in multiple beneficial uses that go further than simply reducing the load of a single pollutant (temperature **AND** nutrients).

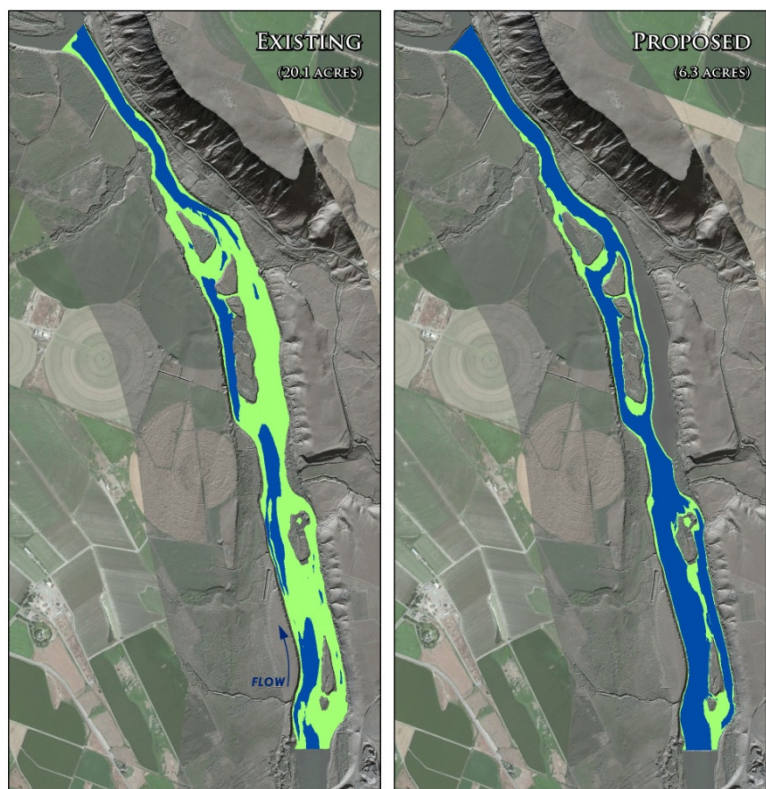


Figure 2. Modeled reduction in macrophyte habitat (depth < 6ft and flow < 3 fps) due to island enhancement.

As described in the opening paragraph, protecting beneficial uses in freshwater ecosystems requires attention to the whole ecosystem structure, not individual components of the ecosystem. The emerging limitation in implementation of the Clean Water Act (and the research and science supporting the implementation of rules therein) is the exclusionary focus on the regulation of single pollutants such as phosphorus, nitrogen, thermal

load, and sediments. This singular focus leads to prescriptive and/or technology controls that measure only isolated inputs rather than the complex array of functional relationships in a healthy ecosystem (Roni et al. 2002; Roni and Beechie 2013). To increase the level of consideration for the full suite of structural habitat features important for functional aquatic ecosystems, regulators and the regulatory community need a way to value the functional relationships between physical instream actions, such as those referenced above, and relevant to water quality drivers (temperature and/or nutrients). Without these relationships, needed restoration of physical processes that are the key to protecting beneficial uses will continue to be delayed in favor of certain but limited one-component solutions.

Regulatory agencies and the research community now need to develop a method that can be used to quantify the benefits of instream actions. Regulatory agencies, and regulated entities need to be able to quantify ecosystem-level benefits in such a way that they are viable compliance options available to NPDES, MSR, and 401 permittees to address thermal load, phosphorus, nitrogen, and dissolved oxygen obligations. The scientific understanding of how channel characteristics promote specific environmental benefits in flow and overall ecosystem health has come to a reasonable consensus over the past decade. The Freshwater Trust proposes that the goal of future research is to support fully beneficial restoration compliance solutions needs link the relationship between channel characteristics and ecological functions, and subsequently, develop the functional relationships between ecological functions and water quality benefits. The end result of this research will be the development of a tool that utilizes these established relationships to predict the water quality responses from instream actions.

The development of a generalized site specific equation that links structural relationships instream with water quality conditions and aquatic functions will provide the technical logic path regulatory agencies will require to implement instream restoration actions as a viable compliance solution.

To support the development of the predictive tool, data will be collected from a number of pilot projects. The collected pilot information can then be used to refine the tool. Additionally, long-term monitoring of ecological functions and water quality parameters at the pilot projects will help to inform future monitoring and refine the tool.

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